X-ray Rocking Curve and Topograph Facilities at CHESS

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On 15th of August, we visited the X-ray facilities at the Cornell High Energy Synchrotron Source (CHESS) and were given a guided tour led by CHESS staff member Ken Finkelstein. He showed us the current experimental beam lines at the CHESS Wilson Synchrotron Lab and gave us a brief description of their facilities. There are no dedicated experimental set-ups for rocking curve and topograph measurements. However, it would be possible to do such measurements there after rearranging their current devices and carrying out some beam line modifications. The expected result would be at least as good as what we got at the Daresbury SRS or could be even better, provided we can get all the necessary help from the CHESS staff. In the following section, I will explain what we learned from this trip.

The electron beam energy in the CESR ring is typically 5 GeV. The distance from the tangent point to the sample position in the CHESS beam lines ranges from 15 meters to 30 meters. Compared to the 80 meters distance at SRS station 7.6, a 20 meters distance is short and it will affect the beam properties such as beam spot size and beam divergence. Fortunately, there is a method that could be used to improve the photon beam properties--that is to use an asymmetric crystal monochromator. The diffraction planes of an asymmetric crystal monochromator are not parallel to the crystal surface, while a symmetric crystal monochrometer has its diffraction planes parallel to the crystal surface. By using an asymmetric crystal monochromator, the X-ray beam divergence can be easily improved, and at the same time, the beam spot size also increased [1]. This is equivalent to moving the sample further downstream from the X-ray source. Using this technique, the X-ray source at CHESS would be well suited to assess the diamond crystal quality for GlueX.

In the CHESS C-1 beam line, there is a 4-circle goniometer. If the step size in the omega circle is small enough, it would be suitable to be used for the diamond measurements. Ken told us that if the current step size is too large, it is possible to do some modifications to reduce it. By using the existing 4-circle goniometer, the diamond samples can be precisely aligned. This is a big improvement compared with the SRS facility, where the goniometer was less flexible in its capability. The reason to use a four-circle goniometer to align the diamond sample is that we intend to do symmetric transmission rocking curves and topographs. For such measurements, the diffraction plane is perpendicular to the crystal surface, and there is no suitable reference surface to guide the alignment. For the reflection symmetric rocking curve and topograph measurements, due to the fact that the diffraction plane is parallel to the crystal surface, it is easier to align the diamond sample. Actually, even for the reflection case, it might be necessary to have a 4-circle goniometer because the diffraction plane may be not strictly

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parallel to the crystal surface; the angle between them can be as large as several degrees, depending on how the crystal was polished.

The detector used to record the rocking curve at the SRS was a single NaI detector. At CHESS, we propose to use a single detector as a starting point and then use a pixel detector later when it is possible. The CHESS staff have a high resolution homemade pixel detector, but it is heavily used. It might be difficult to schedule the use of this detector. Possibly we need to find another pixel detector. The benefit of using a pixel detector is that it produces a 2-dimensional rocking map in a short time period, compared with using a single detector and scanning the whole crystal using a pin-hole beam [2-3]. This 2-dimensional map measures precisely the diamond quality at each point across the crystal. It will let us have a better understanding of the diamond crystal structure.

In summary, we have the impression that CHESS will become a good place for the diamond X-ray rocking curve and topograph measurements for GlueX. By carefully rearranging the current devices they have and making necessary improvements, the expected results would be of higher quality than was possible using the existing setup at the SRS station 7.6.

We also found that the CHESS staff are enthusiastic about this project, and expressed willingness to help us carry out these diamond X-ray measurements. In particular, Ken Finkelstein has valuable experience in X-ray topograph studies [4]. We want to thank Ken and other members of the CHESS staff for the helpful discussions that we had during our visit. We plan to pursue the possibility of carrying out preliminary tests on several diamond samples at CHESS during late 2006.

References

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